CHAPTER 19 (Odd)

1. a. $P_T = 60\text{ W} + 20\text{ W} + 40\text{ W} = \mathbf{120\text{ W}}$

   b. $Q_T = \mathbf{0\text{ VARS}}$, $S_T = P_T = \mathbf{120\text{ VA}}$

   c. $S_T = EI_s, \quad I_s = \dfrac{S_T}{E} = \dfrac{120\text{ VA}}{240\text{ V}} = \mathbf{0.5\text{ A}}$

   d.

$$P = I_s^2 R,\ R = \frac{P}{I_s^2} = \frac{60\text{ W}}{(0.5\text{ A})^2} = 240\ \Omega$$

$$V = I_s R = (0.5\text{ A})(240\ \Omega) = 120\text{ V}$$

$$V_1 = V_2 = E - V = 240\text{ V} - 120\text{ V} = 120\text{ V}$$

$$P_1 = \frac{V_1^2}{R_1},\ R_1 = \frac{V_1^2}{P_1} = \frac{(120\text{ V})^2}{20\text{ W}} = \mathbf{720\ \Omega}$$

$$P_2 = \frac{V_2^2}{R_2},\ R_2 = \frac{V_2^2}{P_2} = \frac{(120\text{ V})^2}{40\text{ W}} = \mathbf{360\ \Omega}$$

   e. $I_1 = \dfrac{V_1}{R_1} = \dfrac{120\text{ V}}{720\ \Omega} = \mathbf{\dfrac{1}{6}\text{ A}},\ I_2 = \dfrac{V_2}{R_2} = \dfrac{120\text{ V}}{360\ \Omega} = \mathbf{\dfrac{1}{3}\text{ A}}$

3. a. $P_T = 0 + 100\text{ W} + 300\text{ W} = \mathbf{400\text{ W}}$

   $Q_T = 200\text{ VAR}(L) - 600\text{ VAR}(C) + 0 = \mathbf{-400\text{ VAR}(C)}$

   $S_T = \sqrt{P_T^2 + Q_T^2} = \mathbf{565.69\text{ VA}}$

   $F_p = \dfrac{P_T}{S_T} = \dfrac{400\text{ W}}{565.69\text{ VA}} = \mathbf{0.7071\text{ (leading)}}$

   b. —

   c.

$$P_T = EI_s \cos\theta_T$$

$$400\text{ W} = (100\text{ V})I_s(0.7071)$$

$$I_s = \frac{400\text{ W}}{70.71\text{ V}} = 5.66\text{ A}$$

$$\mathbf{I}_s = 5.66\text{ A}\ \angle 135^\circ$$

5. a. $P_T = 200\text{ W} + 200\text{ W} + 0 + 100\text{ W} = \mathbf{500\text{ W}}$

   $Q_T = 100\text{ VAR}(L) + 100\text{ VAR}(L) - 200\text{ VAR}(C) - 200\text{ VAR}(C) = \mathbf{-200\text{ VAR}(C)}$

   $S_T = \sqrt{P_T^2 + Q_T^2} = \mathbf{538.52\text{ VA}}$

   b. $F_p = \dfrac{P_T}{S_T} = \dfrac{500\text{ W}}{538.52\text{ VA}} = \mathbf{0.928\text{ (leading)}}$

   c. —

d.
$$P_T = EI_s \cos\theta_T$$
$$500\text{ W} = (50\text{ V})I_s(0.928)$$
$$I_s = \frac{500\text{ W}}{46.4\text{ V}} = 10.776\text{ A}$$
$$\mathbf{I}_s = \mathbf{10.776\text{ A} \angle 21.875°}$$

7. a.
$$R\text{: } P = \frac{E^2}{R} = \frac{(20\text{ V})^2}{2\ \Omega} = \mathbf{200\text{ W}}$$
$$P_{L,C} = \mathbf{0\text{ W}}$$

b.
R: $Q = \mathbf{0\text{ VAR}}$

C: $Q_C = \frac{E^2}{X_C} = \frac{(20\text{ V})^2}{5\ \Omega} = \mathbf{80\text{ VAR}(C)}$

L: $Q_L = \frac{E^2}{X_L} = \frac{(20\text{ V})^2}{4\ \Omega} = \mathbf{100\text{ VAR}(L)}$

c.
R: $S = \mathbf{200\text{ VA}}$
C: $S = \mathbf{80\text{ VA}}$
L: $S = \mathbf{100\text{ VA}}$

d.
$$P_T = 200\text{ W} + 0 + 0 = \mathbf{200\text{ W}}$$
$$Q_T = 0 + 80\text{ VAR}(C) + 100\text{ VAR}(L) = \mathbf{20\text{ VAR}(L)}$$
$$S_T = \sqrt{(200\text{ W})^2 + (20\text{ VAR})^2} = \mathbf{200.998\text{ VA}}$$
$$F_p = \frac{P_T}{S_T} = \frac{200\text{ W}}{200.998\text{ VA}} = \mathbf{0.995\text{ (lagging)}} \Rightarrow 5.73°$$

e. —

f.
$$I_s = \frac{S_T}{E} = \frac{200.998\text{ VA}}{20\text{ V}} = 10.05\text{ A}$$
$$\mathbf{I}_s = 10.05\text{ A} \angle -5.73°$$

9. a–c.

$$X_L = \omega L = (400\text{ rad/s})(0.1\text{ H}) = 40\ \Omega$$
$$X_C = \frac{1}{\omega C} = \frac{1}{(400\text{ rad/s})(100\ \mu\text{F})} = 25\ \Omega$$
$$\mathbf{Z}_1 = 40\ \Omega \angle 90°,\ \mathbf{Z}_2 = 25\ \Omega \angle -90°$$
$$\mathbf{Z}_3 = 30\ \Omega \angle 0°$$

I_s, Z_1, I_2, I_3, +, $E = 50\text{ V} \angle 0°$, +, V_2, Z_2, Z_3, -, -

$$\begin{aligned}\mathbf{Z}_T = \mathbf{Z}_1 + \mathbf{Z}_2 \| \mathbf{Z}_3 &= +j40\ \Omega + (25\ \Omega \angle -90°) \| (30\ \Omega \angle 0°)\\ &= +j40\ \Omega + 19.21\ \Omega \angle -50.19°\\ &= +j40\ \Omega + 12.3\ \Omega - j14.76\ \Omega\\ &= 12.3\ \Omega + j25.24\ \Omega\\ &= 28.08\ \Omega \angle 64.02°\end{aligned}$$

$$\mathbf{I}_s = \frac{\mathbf{E}}{\mathbf{Z}_T} = \frac{50\text{ V} \angle 0°}{28.08\ \Omega \angle 64.02°} = 1.78\text{ A} \angle -64.02°$$
$$\begin{aligned}\mathbf{V}_2 = \mathbf{I}_s(\mathbf{Z}_2 \| \mathbf{Z}_3) &= (1.78\text{ A} \angle -64.02°)(19.21\ \Omega \angle -50.19°)\\ &= 34.19\text{ V} \angle -114.21°\end{aligned}$$

$$\mathbf{I}_2 = \frac{\mathbf{V}_2}{\mathbf{Z}_2} = \frac{34.19 \text{ V} \angle -114.21^\circ}{25 \ \Omega \angle -90^\circ} = 1.37 \text{ A} \angle -24.21^\circ$$

$$\mathbf{I}_3 = \frac{\mathbf{V}_2}{\mathbf{Z}_3} = \frac{34.19 \text{ V} \angle -114.21^\circ}{30 \ \Omega \angle 0^\circ} = 1.14 \text{ A} \angle -114.21^\circ$$

$\mathbf{Z}_1$: $P = \mathbf{0\ W}$, $Q_L = I_s^2 X_L = (1.78 \text{ A})^2\, 40\ \Omega = \mathbf{126.74\ VAR}(\boldsymbol{L})$
$\mathbf{Z}_2$: $P = \mathbf{0\ W}$, $Q_C = I_2^2 X_C = (1.37 \text{ A})^2\, 25\ \Omega = \mathbf{46.92\ VAR}(\boldsymbol{C})$
$\mathbf{Z}_3$: $P = I_3^2 R = (1.14 \text{ A})^2\, 30\ \Omega = \mathbf{38.99\ W}$, $Q_R = \mathbf{0\ VAR}$

d. $P_T = 0 + 0 + 38.99 \text{ W} = \mathbf{38.99\ W}$
$Q_T = +126.74 \text{ VAR}(L) - 46.92 \text{ VAR}(C) + 0 = \mathbf{79.82\ VAR}(\boldsymbol{L})$

$$S_T = \sqrt{P_T^2 + Q_T^2} = \mathbf{88.83\ VA}$$

$$F_p = \frac{P_T}{S_T} = \frac{38.99 \text{ W}}{88.83 \text{ VA}} = \mathbf{0.439\ (lagging)}$$

e. —

f. $$W_R = \frac{V_R I_R}{2f_1} = \frac{V_2 I_3}{2f_1} = \frac{(34.19 \text{ V})(1.14 \text{ A})}{2(63.69 \text{ Hz})} = \mathbf{0.31\ J}$$

$$f_1 = \frac{\omega_1}{2\pi} = \frac{400 \text{ rad/s}}{6.28} = 63.69 \text{ Hz}$$

g. $$W_L = \frac{V_L I_L}{\omega_1} = \frac{(I_s X_L) I_s}{\omega_1} = \frac{I_s^2 X_L}{\omega_1} = \frac{(1.78 \text{ A})^2\, 40\ \Omega}{400 \text{ rad/s}} = \mathbf{0.32\ J}$$

$$W_C = \frac{V_C I_C}{\omega_1} = \frac{V_2 I_2}{\omega_1} = \frac{(34.19 \text{ V})(1.37 \text{ A})}{400 \text{ rad/s}} = \mathbf{0.12\ J}$$

11. a. $$I = \frac{S_T}{E} = \frac{5000 \text{ VA}}{120 \text{ V}} = 41.67 \text{ A}$$

$F_p = 0.8 \Rightarrow 36.87^\circ$ (lagging)
$\mathbf{E} = 120 \text{ V} \angle 0^\circ$, $\mathbf{I} = 41.67 \text{ A} \angle -36.87^\circ$

$$\mathbf{Z} = \frac{\mathbf{E}}{\mathbf{I}} = \frac{120 \text{ V} \angle 0^\circ}{41.67 \text{ A} \angle -36.87^\circ} = 2.88\ \Omega \angle 36.87^\circ = \mathbf{2.30\ \Omega + \mathit{j}1.73\ \Omega} = R + jX_L$$

b. $P = S\cos\theta = (5000 \text{ VA})(0.8) = \mathbf{4000\ W}$

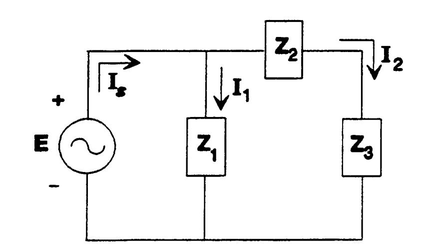
13. a. $P_T = 0 + 300 \text{ W} + 600 \text{ W} = \mathbf{900\ W}$
$Q_T = 500 \text{ VAR}(C) + 0 + 500 \text{ VAR}(L) = \mathbf{0\ VAR}$
$S_T = P_T = \mathbf{900\ VA}$

$$F_p = \frac{P_T}{S_T} = \mathbf{1}$$

b. $$I_s = \frac{S_T}{E} = \frac{900 \text{ VA}}{100 \text{ V}} = 9 \text{ A}, \ \mathbf{I}_s = \mathbf{9\ A \angle 0^\circ}$$

c. —

d.



$$\mathbf{Z}_1: \quad Q_C = \frac{V^2}{X_C} \Rightarrow X_C = \frac{V^2}{Q_C} = \frac{10^4}{500} = \mathbf{20\ \Omega}$$

$$\mathbf{I}_1 = \frac{\mathbf{E}}{\mathbf{Z}_1} = \frac{100\text{ V} \angle 0°}{20\ \Omega \angle -90°} = 5\text{A} \angle 90°$$

$$\mathbf{I}_2 = \mathbf{I}_s - \mathbf{I}_1 = 9\text{ A} - j5\text{ A} = 10.296\text{ A} \angle -29.05°$$

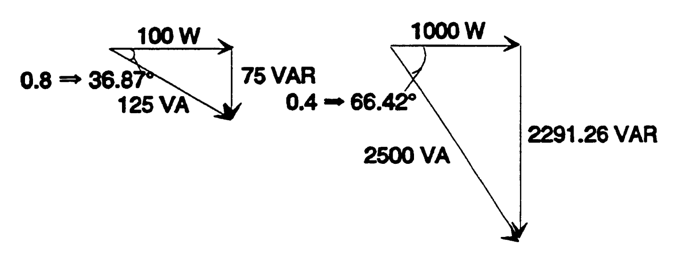
$$\mathbf{Z}_2: \quad R = \frac{P}{I^2} = \frac{300\text{ W}}{(10.296\text{ A})^2} = \frac{300}{106} = \mathbf{2.83\ \Omega}$$

$$X_{L,C} = \mathbf{0\ \Omega}$$

$$\mathbf{Z}_3: \quad R = \frac{P}{I_2^2} = \frac{600\text{ W}}{(10.296\text{ A})^2} = \mathbf{5.66\ \Omega}$$

$$X_L = \frac{Q}{I_2^2} = \frac{500}{(10.296\text{ A})^2} = \mathbf{4.717\ \Omega},\ X_C = \mathbf{0\ \Omega}$$

15. a. $P_T = 100\text{ W} + 1000\text{ W} = \mathbf{1100\text{ W}}$



$$Q_T = 75\text{ VAR}(C) + 2291.26\text{ VAR}(C) = \mathbf{2366.26\text{ VAR}(C)}$$

$$S_T = \sqrt{P_T^2 + Q_T^2} = \mathbf{2609.44\text{ VA}}$$

$$F_p = \frac{P_T}{S_T} = \frac{1100\text{ W}}{2609.44\text{ VA}} = \mathbf{0.4215\text{ (leading)}} \Rightarrow 65.07°$$

b. $S_T = EI \Rightarrow E = \dfrac{S_T}{I} = \dfrac{2609.44\text{ VA}}{5\text{ A}} = 521.89\text{ V}$

$$\mathbf{E} = \mathbf{521.89\text{ V} \angle -65.07°}$$

c.

$$I_{Z_1} = \frac{S}{V_1} = \frac{S}{E} = \frac{125\text{ VA}}{521.89\text{ V}} = 0.2395\text{ A}$$

$$I_{Z_2} = \frac{S}{V_2} = \frac{S}{E} = \frac{2500\text{ VA}}{521.89\text{ V}} = 4.79\text{ A}$$

$$\mathbf{Z}_1: \quad R = \frac{P}{I_{Z_1}^2} = \frac{100\text{ W}}{(0.2395)^2} = \mathbf{1743.38\ \Omega}$$

$$Q = I_{Z_1}^2 X_C \Rightarrow X_C = \frac{Q}{I_{Z_1}^2} = \frac{75\text{ VAR}}{(0.2395\text{ A})^2} = \mathbf{1307.53\ \Omega}$$

$$\mathbf{Z}_2: \quad R = \frac{P}{I_{Z_2}^2} = \frac{1000\text{ W}}{(4.790\text{ A})^2} = \mathbf{43.59\ \Omega}$$

$$X_C = \frac{Q}{I_{Z_2}^2} = \frac{2291.26\text{ VAR}}{(4.790\text{ A})^2} = \mathbf{99.88\ \Omega}$$

17. a. $P_T = 5\text{ kW}, Q_T = 6\text{ kVAR}(L)$

$$S_T = \sqrt{P_T^2 + Q_T^2} = \mathbf{7.81\text{ kVA}}$$

b. $$F_p = \frac{P_T}{S_T} = \frac{5\text{ kW}}{7.81\text{ kVA}} = \mathbf{0.640\text{ (lagging)}}$$

c. $$I_s = \frac{S_T}{E} = \frac{7{,}810\text{ VA}}{120\text{ V}} = \mathbf{65.08\text{ A}}$$

d. $$X_C = \frac{1}{2\pi fC},\ Q_C = I^2X_C = \frac{E^2}{X_C} = \frac{(120\text{ V})^2}{X_C}$$

and $$X_C = \frac{(120\text{ V})^2}{Q_C} = \frac{14{,}400}{6000} = 2.4\ \Omega$$

$$C = \frac{1}{2\pi fX_C} = \frac{1}{(2\pi)(60\text{ Hz})(2.4\ \Omega)} = \mathbf{1105\ \mu F}$$

e. $S_T = EI_s = P_T$

$$\therefore I_s = \frac{P_T}{E} = \frac{5000\text{ W}}{120\text{ V}} = \mathbf{41.67\text{ A}}$$

19. a. $\mathbf{Z}_T = R_1 + R_2 + R_3 + jX_L - jX_C$
$= 2\ \Omega + 3\ \Omega + 1\ \Omega + j3\ \Omega - j12\ \Omega = 6\ \Omega - j9\ \Omega = 10.82\ \Omega\ \angle -56.31°$

$$\mathbf{I} = \frac{\mathbf{E}}{\mathbf{Z}_T} = \frac{50\text{ V}\ \angle 0°}{10.82\ \Omega\ \angle -56.31°} = 4.62\text{ A}\ \angle 56.31°$$

$P = VI\cos\theta = (50\text{ V})(4.62\text{ A})\cos 56.31° = \mathbf{128.14\text{ W}}$

b. a-b: $P = I^2R = (4.62\text{ A})^2\ 2\ \Omega = \mathbf{42.69\text{ W}}$
b-c: $P = I^2R = (4.62\text{ A})^2\ 3\ \Omega = \mathbf{64.03\text{ W}}$
a-c: $42.69\text{ W} + 64.03\text{ W} = \mathbf{106.72\text{ W}}$
a-d: **106.72 W**
c-d: **0 W**
d-e: **0 W**
f-e: $P = I^2R = (4.62\text{ A})^2\ 1\ \Omega = \mathbf{21.34\text{ W}}$

21. a. $R = \dfrac{P}{I^2} = \dfrac{80\ \text{W}}{(4\ \text{A})^2} = 5\ \Omega,\ Z_T = \dfrac{E}{I} = \dfrac{200\ \text{V}}{4\ \text{A}} = 50\ \Omega$

$$X_L = \sqrt{Z_T^2 - R^2} = \sqrt{(50\ \Omega)^2 - (5\ \Omega)^2} = 49.75\ \Omega$$

$$L = \frac{X_L}{2\pi f} = \frac{49.75\ \Omega}{(2\pi)(60\ \text{Hz})} = \mathbf{132.03\ mH}$$

b. $R = \dfrac{P}{I^2} = \dfrac{90\ \text{W}}{(3\ \text{A})^2} = \mathbf{10\ \Omega}$

c. $R = \dfrac{P}{I^2} = \dfrac{60\ \text{W}}{(2\ \text{A})^2} = \mathbf{15\ \Omega},\ Z_T = \dfrac{E}{I} = \dfrac{200\ \text{V}}{2\ \text{A}} = 100\ \Omega$

$$X_L = \sqrt{Z_T^2 - R^2} = \sqrt{(100\ \Omega)^2 - (15\ \Omega)^2} = 98.87\ \Omega$$

$$L = \frac{X_L}{2\pi f} = \frac{98.87\ \Omega}{376.8} = \mathbf{262.39\ mH}$$

CHAPTER 19 (Even)

2. a. $\mathbf{Z}_T = 3\ \Omega - j5\ \Omega + j9\ \Omega = 3\ \Omega + j4\ \Omega = 5\ \Omega\ \angle 53.13°$

$$\mathbf{I} = \frac{\mathbf{E}}{\mathbf{Z}_T} = \frac{50\ \text{V}\ \angle 0°}{5\ \Omega\ \angle 53.13°} = 10\ \text{A}\ \angle -53.13°$$

R: $P = I^2R = (10\ \text{A})^2\ 3\ \Omega = \mathbf{300\ W}$
L: $P = \mathbf{0\ W}$
C: $P = \mathbf{0\ W}$

b. R: $Q = \mathbf{0\ VAR}$
C: $Q_C = I^2X_C = (10\ \text{A})^2\ 5\ \Omega = \mathbf{500\ VAR}$
L: $Q_L = I^2X_L = (10\ \text{A})^2\ 9\ \Omega = \mathbf{900\ VAR}$

c. R: $S = \mathbf{300\ VA}$
C: $S = \mathbf{500\ VA}$
L: $S = \mathbf{900\ VA}$

d. $P_T = 300\ \text{W}$
$Q_T = Q_L - Q_C = \mathbf{400\ VAR}(L)$

$$S_T = \sqrt{P_T^2 + Q_T^2} = EI = (50\ \text{V})(10\ \text{A}) = \mathbf{500\ VA}$$

$$F_p = \frac{P_T}{S_T} = \frac{300\ \text{W}}{500\ \text{VA}} = \mathbf{0.6\ lagging}$$

e. —

f. $$W_R = \frac{VI}{f_1}:\ W_R = 2\left[\frac{VI}{f_2}\right] = 2\left[\frac{VI}{2f_1}\right] = \frac{VI}{f_1}$$

$V = IR = (10\ \text{A})(3\ \Omega) = 30\ \text{V}$

$$W_R = \frac{(30\ \text{V})(10\ \text{A})}{60\ \text{Hz}} = \mathbf{5\ J}$$

g. $V_C = IX_C = (10\ \text{A})(5\ \Omega) = 50\ \text{V}$

$$W_C = \frac{VI}{\omega_1} = \frac{(50\ \text{V})(10\ \text{A})}{(2\pi)(60\ \text{Hz})} = \mathbf{1.327\ J}$$

$V_L = IX_L = (10\ \text{A})(9\ \Omega) = 90\ \text{V}$

$$W_L = \frac{VI}{\omega_1} = \frac{(90\ \text{V})(10\ \text{A})}{376.8} = \mathbf{2.389\ J}$$

4. a. $P_T = 600\ \text{W} + 500\ \text{W} + 100\ \text{W} = \mathbf{1200\ W}$
$Q_T = 1200\ \text{VAR}(L) + 600\ \text{VAR}(L) - 600\ \text{VAR}(C) = \mathbf{1200\ VAR}(L)$

$$S_T = \sqrt{P_T^2 + Q_T^2} = \sqrt{(1200\ \text{W})^2 + (1200\ \text{VAR})^2} = \mathbf{1697\ VA}$$

b. $$F_p = \frac{P_T}{S_T} = \frac{1200\ \text{W}}{1697\ \text{VA}} = \mathbf{0.7071\ (lagging)}$$

c. —

d. $I_s = \frac{S_T}{E} = \frac{1697 \text{ VA}}{200 \text{ V}} = 8.485 \text{ A}, 0.7071 \Rightarrow 45° \text{ (lagging)}$

$\mathbf{I}_s = \mathbf{8.485 \text{ A} \angle -45°}$

6. a. $\mathbf{I}_R = \frac{60 \text{ V} \angle 30°}{20\ \Omega \angle 0°} = 3 \text{ A} \angle 30°$

$P = I^2R = (3 \text{ A})^2\, 20\ \Omega = \mathbf{180 \text{ W}}$

$Q_R = \mathbf{0 \text{ VAR}}$

$S = P = \mathbf{180 \text{ VA}}$

b. $\mathbf{I}_L = \frac{60 \text{ V} \angle 30°}{10\ \Omega \angle 90°} = 6 \text{ A} \angle -60°$

$P_L = \mathbf{0 \text{ W}}$

$Q_L = I^2X_L = (6 \text{ A})^2\, 10\ \Omega = \mathbf{360 \text{ VAR}(L)}$

$S = Q = \mathbf{360 \text{ VA}}$

c. $P_T = 180 \text{ W} + 400 \text{ W} = \mathbf{580 \text{ W}}$

$Q_T = 600 \text{ VAR}(L) + 360 \text{ VAR}(L) = \mathbf{960 \text{ VAR}(L)}$

$S_T = \sqrt{(580 \text{ W})^2 + (960 \text{ VAR})^2} = \mathbf{1121.61 \text{ VA}}$

$F_p = \frac{P_T}{S_T} = \frac{580 \text{ W}}{1121.61 \text{ VA}} = \mathbf{0.517 \text{ (lagging)}} \quad \theta = 58.87°$

d. $S_T = EI_s$

$I_s = \frac{S_T}{E} = \frac{1121.61 \text{ VA}}{60 \text{ V}} = 18.69 \text{ A}$

$\theta_{I_s} = 30° - 58.87° = -28.87°$

$\mathbf{I}_s = \mathbf{18.69 \text{ A} \angle -28.87°}$

8. a. $R - L$: $\quad \mathbf{I} = \frac{50 \text{ V} \angle 60°}{5\ \Omega \angle 53.13°} = 10 \text{ A} \angle 6.87°$

$P_R = I^2R = (10 \text{ A})^2\, 3\ \Omega = \mathbf{300 \text{ W}}$

$P_L = \mathbf{0 \text{ W}}$

$P_C = \mathbf{0 \text{ W}}$

b. $Q_R = \mathbf{0 \text{ VAR}}$

$Q_L = I^2X_L = (10 \text{ A})^2\, 4\ \Omega = \mathbf{400 \text{ VAR}}$

$\mathbf{I}_C = \frac{50 \text{ V} \angle 60°}{10\ \Omega \angle -90°} = 5 \text{ A} \angle 150°$

$Q_C = I^2X_C = (5 \text{ A})^2\, 10\ \Omega = \mathbf{250 \text{ VAR}}$

c. $S_R = P = \mathbf{300 \text{ VA}}$

$S_L = Q_L = \mathbf{400 \text{ VA}}$

$S_C = Q_C = \mathbf{250 \text{ VA}}$

d. $P_T = P_R = \mathbf{300 \text{ W}}$

$Q_T = 400 \text{ VAR}(L) - 250 \text{ VAR}(C) = \mathbf{150 \text{ VAR}(L)}$

$S_T = \sqrt{(300 \text{ W})^2 + (150 \text{ VAR})^2} = \mathbf{335.41 \text{ VA}}$

$$F_p = \frac{P_T}{S_T} = \frac{300 \text{ W}}{335.41 \text{ VA}} = \mathbf{0.894 \text{ (lagging)}}$$

e. —

f. $I_s = \frac{S_T}{E} = \frac{335.41 \text{ VA}}{50 \text{ V}} = 6.71 \text{ A}$

$0.894 \Rightarrow 26.62°$ lagging

$\theta = 60° - 26.62° = 33.38°$

$\mathbf{I}_s = \mathbf{6.71 \text{ A} \angle 33.38°}$

10. a. $I_s = \frac{S_T}{E} = \frac{10{,}000 \text{ VA}}{200 \text{ V}} = 50 \text{ A}$

$0.5 \Rightarrow 60°$ leading

$\therefore I_s$ leads **E** by $60°$

$$\mathbf{Z}_T = \frac{\mathbf{E}}{\mathbf{I}_s} = \frac{200 \text{ V} \angle 0°}{50 \text{ A} \angle 60°} = 4 \text{ Ω} \angle -60° = 2 \text{ Ω} - j3.464 \text{ Ω} = R - jX_C$$

b. $F_p = \frac{P_T}{S_T} \Rightarrow P_T = F_p S_T = (0.5)(10{,}000 \text{ VA}) = \mathbf{5000 \text{ W}}$

12. a. $P_T = 0 + 300 \text{ W} = \mathbf{300 \text{ W}}$

$Q_T = 600 \text{ VAR}(C) + 200(L) = \mathbf{400 \text{ VAR}(C)}$

$S_T = \sqrt{P_T^2 + Q_T^2} = \mathbf{500 \text{ VA}}$

$F_p = \frac{P_T}{S_T} = \frac{300 \text{ W}}{500 \text{ VA}} = \mathbf{0.6 \text{ (leading)}}$

b. $I_s = \frac{S_T}{E} = \frac{500 \text{ VA}}{30 \text{ V}} = 16.67 \text{ A}$

$F_p = 0.6 \Rightarrow 53.13°$

$\mathbf{I}_s = \mathbf{16.67 \text{ A} \angle 53.13°}$

c. —

d. Load: 600 VAR(C), 0 W

$$R = 0, L = 0, Q_C = I^2 X_C \Rightarrow X_C = \frac{Q_C}{I^2} = \frac{600 \text{ VAR}}{(16.67 \text{ A})^2} = \mathbf{2.159 \text{ Ω}}$$

Load: 200 VAR(L), 300 W

$C = 0, R = P/I^2 = 300 \text{ W}/(16.67 \text{ A})^2 = \mathbf{1.079 \text{ Ω}}$

$X_L = \frac{Q_L}{I^2} = \frac{200 \text{ VAR}}{(16.67 \text{ A})^2} = \mathbf{0.7197 \text{ Ω}}$

$\mathbf{Z}_T = -j2.159 \text{ Ω} + 1.0796 \text{ Ω} + j0.7197 \text{ Ω}$

$= \mathbf{1.0796 \text{ Ω} - j1.4393 \text{ Ω}}$

14. a. $P_T = 200 \text{ W} + 30 \text{ W} + 0 = \mathbf{230 \text{ W}}$

$Q_T = 0 + 40 \text{ VAR}(L) + 100 \text{ VAR}(L) = \mathbf{140 \text{ VAR}(L)}$

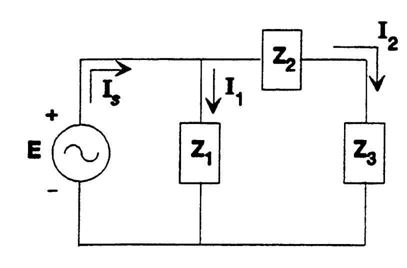
$S_T = \sqrt{P_T^2 + Q_T^2} = \mathbf{269.26 \text{ VA}}$

$$F_p = \frac{P_T}{S_T} = \frac{230\text{ W}}{269.26\text{ VA}} = \mathbf{0.854\ (lagging)} \Rightarrow 31.35°$$

b. $$I_s = \frac{S_T}{E} = \frac{269.26\text{ VA}}{100\text{ V}} = 2.6926\text{ A}$$

$$\mathbf{I}_s = 2.6926\text{ A} \angle -31.35°$$

c.



$$\mathbf{Z}_1: \quad R = \frac{V^2}{P} = \frac{10^4}{200} = 50\ \Omega$$

$$X_L, X_C = 0\ \Omega$$

$$\mathbf{I}_1 = \frac{100\text{ V} \angle 0°}{50\ \Omega \angle 0°} = 2\text{ A} \angle 0°$$

$$\begin{aligned}\mathbf{I}_2 &= \mathbf{I}_s - \mathbf{I}_1 \\ &= 2.6926\text{ A} \angle -31.35° - 2\text{ A} \angle 0° \\ &= 2.299\text{ A} - j1.40\text{ A} - 2.0\text{ A} \\ &= 0.299\text{ A} - j1.40\text{ A} \\ &= 1.432\text{ A} \angle -77.94°\end{aligned}$$

$$\mathbf{Z}_2: \quad R = \frac{P}{I_2^2} = \frac{30\text{ W}}{(1.432\text{ A})^2} = \mathbf{14.63\ \Omega},\ X_L = \frac{Q}{I_2^2} = \frac{40\text{ VAR}}{(1.432\text{ A})^2} = \mathbf{19.50\ \Omega}$$

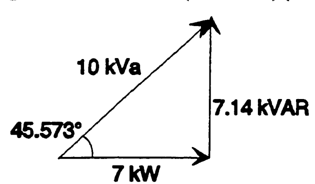
$$X_C = \mathbf{0\ \Omega}$$

$$\mathbf{Z}_3: \quad X_L = \frac{Q}{I_2^2} = \frac{100\text{ VAR}}{(1.432\text{ A})^2} = \mathbf{48.76\ \Omega},\ R = \mathbf{0\ \Omega},\ X_C = \mathbf{0\ \Omega}$$

16. a. $0.7 \Rightarrow 45.573°$

$$P = S\cos\theta = (10\text{ kVA})(0.7) = 7\text{ kW}$$

$$Q = S\sin\theta = (10\text{ kVA})(0.714) = 7.14\text{ kVAR}(L)$$



b. $$Q_C = 7.14\text{ kVAR} = \frac{V^2}{X_C}$$

$$X_C = \frac{V^2}{Q_C} = \frac{(208\text{ V})^2}{7.14\text{ kVAR}} = 6.059\ \Omega$$

$$X_C = \frac{1}{2\pi fC} \Rightarrow C = \frac{1}{2\pi fX_C} = \frac{1}{(2\pi)(60\text{ Hz})(6.059\ \Omega)} = \mathbf{438\ \mu F}$$

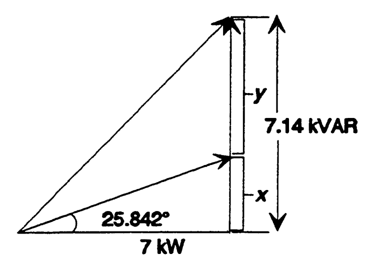
c. Uncompensated:

$$I_s = \frac{S_T}{E} = \frac{10{,}000\text{ VA}}{208\text{ V}} = \mathbf{48.08\ A}$$

Compensated:

$$I_s = \frac{S_T}{E} = \frac{P_T}{E} = \frac{7{,}000\text{ W}}{208\text{ V}} = \mathbf{33.65\ A}$$

d.



$\cos\theta = 0.9$
$\theta = \cos^{-1}0.9 = 25.842°$
$\tan\theta = \dfrac{x}{7\text{ kW}}$
$x = (7\text{ kW})(\tan 25.842°)$
$= (7\text{ kW})(0.484)$
$= 3.39\text{ kVAR}$
$y = (7.14 - 3.39)\text{ kVAR}$
$= 3.75\text{ kVAR}$

$$Q_C = 3.75\text{ kVAR} = \frac{V^2}{X_C}$$

$$X_C = \frac{V^2}{Q_C} = \frac{(208\text{ V})^2}{3.75\text{ kVAR}} = 11.537\ \Omega$$

$$C = \frac{1}{2\pi f X_C} = \frac{1}{(2\pi)(60\text{ Hz})(11.537\ \Omega)} = \mathbf{230\ \mu F}$$

Uncompensated:

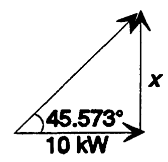
$I_s = \mathbf{48.08\ A}$

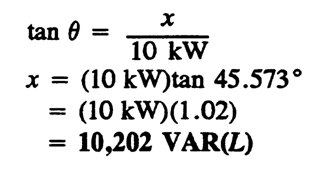
Compensated:

$$S_T = \sqrt{(7\text{ kW})^2 + (3.39\text{ kVAR})^2} = 7.778\text{ kVA}$$

$$I_s = \frac{S_T}{E} = \frac{7.778\text{ kVA}}{208\text{ V}} = \mathbf{37.39\ A}$$

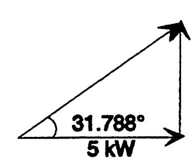
18. a. Load 1: $P = 20{,}000\text{ W},\ Q = 0\text{ VAR}$
Load 2: $\theta = \cos^{-1}0.7 = 45.573°$





$\tan\theta = \dfrac{x}{10\text{ kW}}$
$x = (10\text{ kW})\tan 45.573°$
$= (10\text{ kW})(1.02)$
$= \mathbf{10{,}202\ VAR}(L)$

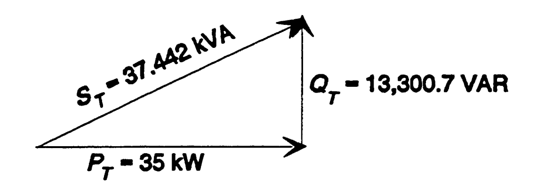
Load 3: $\theta = \cos^{-1}0.85 = 31.788°$



$\tan\theta = \dfrac{x}{5\text{ kW}}$
$x = (5\text{ kW})\tan 31.788°$
$= (5\text{ kW})(0.62)$
$= 3098.7\text{ VAR}(L)$

$P_T = 20{,}000\text{ W} + 10{,}000\text{ W} + 5{,}000\text{ W} = \mathbf{35\ kW}$
$Q_T = 0 + 10{,}202\text{ VAR} + 3098.7\text{ VAR} = \mathbf{13{,}300.7\ VAR}(L)$

$$S_T = \sqrt{P_T^2 + Q_T^2} = \mathbf{37{,}442\ VA} = \mathbf{37.442\ kVA}$$



b. $Q_C = Q_L = 13{,}300.7\text{ VAR}$

$$X_C = \frac{E^2}{Q_C} = \frac{(10^3\text{ V})^2}{13{,}300.7\text{ VAR}} = 75.184\ \Omega$$

$$C = \frac{1}{2\pi f X_C} = \frac{1}{(2\pi)(60\text{ Hz})(75.184\ \Omega)} = \mathbf{35.28\ \mu F}$$

c. Uncompensated:

$$I_s = \frac{S_T}{E} = \frac{37.442\text{ kVA}}{1\text{ kV}} = \mathbf{37.442\text{ A}}$$

Compensated:

$$S_T = P_T = 35\text{ kW}$$

$$I_s = \frac{S_T}{E} = \frac{35\text{ kW}}{1\text{ kV}} = \mathbf{35\text{ A}}$$

20. a. $S_T = 660\text{ VA} = EI_s$

$$I_s = \frac{660\text{ VA}}{120\text{ V}} = 5.5\text{ A}$$

$$\theta = \cos^{-1}0.6 = 53.13^\circ$$

$$\therefore \mathbf{E} = 120\text{ V}\ \angle 0^\circ,\ \mathbf{I}_s = 5.5\text{ A}\ \angle -53.13^\circ$$

$$P = EI\cos\theta = (120\text{ V})(5.5\text{ A})(0.6) = \mathbf{396\text{ W}}$$

Wattmeter = **396 W**, Ammeter = **5.5 A**, Voltmeter = **120 V**

b. $$\mathbf{Z}_T = \frac{\mathbf{E}}{\mathbf{I}} = \frac{120\text{ V}\ \angle 0^\circ}{5.5\text{ A}\ \angle -53.13^\circ} = \mathbf{21.82\ \Omega\ \angle 53.13^\circ} = \mathbf{13.09\ \Omega + j17.46\ \Omega} = R + jX_L$$

22. a. $X_L = 2\pi fL = (6.28)(50\text{ Hz})(0.08\text{ H}) = 25.12\ \Omega$

$$Z_T = \sqrt{R^2 + X_L^2} = \sqrt{(4\ \Omega)^2 + (25.12\ \Omega)^2} = 25.44\ \Omega$$

$$I = \frac{E}{Z_T} = \frac{60\text{ V}}{25.44\ \Omega} = 2.358\text{ A}$$

$$P = I^2R = (2.358\text{ A})^2\ 4\ \Omega = \mathbf{22.24\text{ W}}$$

b. $$I = \sqrt{\frac{P}{R}} = \sqrt{\frac{30\text{ W}}{7\ \Omega}} = \mathbf{2.07\text{ A}}$$

$$Z_T = \frac{E}{I} = \frac{60\text{ V}}{2.07\text{ A}} = 28.99\ \Omega$$

$$X_L = \sqrt{(28.99\ \Omega)^2 - (7\ \Omega)^2} = 28.13\ \Omega$$

$$L = \frac{X_L}{2\pi f} = \frac{28.13\ \Omega}{(2\pi)(50\text{ Hz})} = \mathbf{89.54\text{ mH}}$$

c. $P = I^2R = (1.7\text{ A})^2\ 10\ \Omega = \mathbf{28.9\text{ W}}$

$$Z_T = \frac{E}{I} = \frac{60\text{ V}}{1.7\text{ A}} = 35.29\ \Omega$$

$$X_L = \sqrt{(35.29\ \Omega)^2 - (10\ \Omega)^2} = 33.84\ \Omega$$

$$L = \frac{X_L}{2\pi f} = \frac{38.84\ \Omega}{314} = \mathbf{107.77\text{ mH}}$$